

Cloud Computing Services for the Healthcare Industry

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Abstract— Healthcare sector is facing a number of challenges like high IT costs, more processing power, ubiquitous access, scalability and demand for interoperability etc. Present health technology is deficient to address these challenges. Cloud computing having qualities such as multi-tenancy, flexibility and metered delivery appears a viable approach. This paper reviews the state-of-the-art cloud computing paradigm, presents a cloud driven healthcare service model, and explores different services of cloud for health industry. Paper also shed light on the constraints associated with cloud adoption for healthcare. Paper concludes that healthcare stakeholders can take advantage of cloud services to offer novel patient care applications, reduce costs and management, and ultimately provide quality healthcare services.

Keywords– Cloud Computing, Health Care, Challenges and Services

I. INTRODUCTION

In the recent years, the cloud computing hype has attracted many businesses, organizations and institutions that require collaborative, flexible, scalable and cost effective computational infrastructure. Healthcare industry too is getting fascinated by this surge. Leading information technology (IT) companies like Google, Microsoft, and Amazon etc have extended their cloud services for medical world [7]. According to a study [16], cloud market invested USD1.82 billion in healthcare industry during fiscal year 2011 and it is estimated to climb up USD6.79 billion in year 2018. Healthcare industry encompass all the stakeholders including medical care centers, physicians, allied staff, policy makers, academia, research groups, pharmaceuticals companies, bio-informatics community and masses. Industry strives for world

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health organization (WHO) slogan “Health for All”. However, healthcare organizations suffer from a number of challenges like scarcity of human resource, high IT costs, scalability of computational resources, and demand for collaboration etc. Cloud computing is seen as a solution to alike problems in healthcare [14], [1], [7]. This research presents a conceptual cloud based healthcare service model as well as answers the questions like: What is cloud computing? Why organizations should shift their solutions to cloud? Which services cloud can provide to them? What advantages they can earn? What are the potential risks? Paper is organized as follows: next section presents an overview of the cloud computing, cloud services to the healthcare industry are explored and discussed in section three, section four details cloud adoption risks, and last section concludes the paper.

II. CLOUD COMPUTING

Cloud computing has freshly come out as a new sculpt for delivering and hosting Information Technology (IT) services over the internet. It provides services that are on-demand, scalable, and multi-tenant on the pay-per-use basis.

Several definitions have been given for cloud computing model but no one is standard definition that describes it completely. However, National Institute of Standards and Technology (NIST) defines it as “Cloud computing is a model for facilitating well-situated, on-demand network access to a shared band of configurable computing resources like networks, servers, storage, applications, and services that can be rapidly provisioned and released with minimal management effort or service provider interaction” [12].

NIST cloud framework also defines five key attributes, three service models, and four deployment models. These essential service attributes include on demand self service, broad network access, resource pooling, rapid elasticity and measured service.

A. Service Models

Following are the service models of cloud computing:

Software-as-service (SaaS): SaaS provides various software applications which clients can use without having to install them on their machines. These services like e-mail, facebook,

and google docs are accessible from any device having a web browser.

Platform-as-a-service (PaaS): It comprises a set of software development and deployment technologies e.g. operating systems, application development environment, databases, and web servers. People can use these services either to host or to develop and test their applications. Microsoft Azure, Google AppEngine and Amazon SimpleDB/S3 are some examples of PaaS.

Infrastructure as a service (IaaS): This model offers an organization with services like processing, storage and network bandwidth. Businesses and institutions can purchase these compute and I/O services to meet their application demands [4]. Examples include GoGrid, FlexiScale, AmazonEC2 etc.

B. Deployment Models

Four deployment models of cloud computing are as follows:

Public cloud: Public cloud as its name suggests 'Public' is available to general public. It is economical cloud that is stand-alone, proprietary based and off-premises. In house and small businesses use public cloud mostly to meet their requirements.

Private cloud: Big organizations use private cloud to serve their business needs internally. Private cloud is more secure, well configured and expensive as it is not shared. Private cloud is usually on-premises.

Community cloud: Organizations that have similar requirements and business targets they use community cloud. It is just like public cloud but only for the participating groups with enhanced security and privacy control. It can be located on-premises or off-premises.

Hybrid cloud: Hybrid Cloud is a combination of two or more clouds (private, community or public). Hybrid cloud is a single cloud that provides blend of shared services. The major issue of hybrid cloud is its security and control [4]. Hybrid cloud can be on user or on provider's premises.

III. CLOUD COMPUTING BASED HEALTHCARE SERVICES

Healthcare industry has been using new technologies to streamline processes, deliver novel patient care applications and ultimately to provide improved healthcare services. Despite the use of IT solutions, healthcare organizations face the challenges such as high infrastructure management costs, dynamic needs for computational resources, scalability of human resources, ubiquitous access, multi-tenancy and increased demand for collaboration. These key challenges vouch for the introduction of cloud computing in healthcare organizations. The five essential characteristics of the cloud adequately address these challenges.

- *On-demand service*: resources can be provisioned immediately without any human intervention.
- *Broad network access*: services can be accessed from any location at any time.

- *Resource pooling*: several users may utilize the services simultaneously.
- *Elasticity*: resources can be added or removed to suit the organizational needs.
- *Measured service*: clients only pay for what they have used.

Using cloud it is quite easy to get healthcare services over the internet using a web browser on a range of devices.

Figure 1, presents cloud driven healthcare service model. Model could be used as a reference to provide various services to the healthcare industry. Following is the description of these cloud services to the medical industry that can improve the traditional healthcare procedures and reduce management overhead and cost of IT procurement.

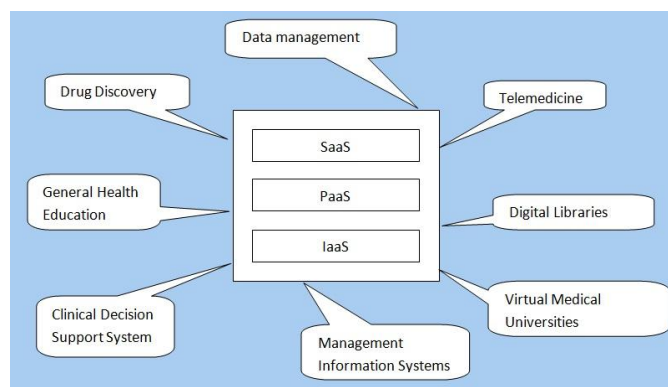


Figure 1: Cloud driven healthcare services

A. Data Management

Data management is a prime issue in healthcare industry. Point of care centers, particularly, have to store and maintain pica bytes of data about human resource, account files and patient medical records including patient history, diagnosis, treatment, dietary information etc. Traditional approach of in-house data maintenance incurs a big investment on IT staff and storage infrastructure [2]. Furthermore, issues like data loss, data theft, data availability and data integrity remain common to the data center.

Cloud data storage and maintenance frameworks like HDFS, Hive, HBase etc offer a cost effective solution to the problem with increased security and ease of management [2]. In addition to this, cloud storage benefits include:

- It increases the data availability. Clinicians can access the data 24/7 from any place they want.
- Physicians can share the data with other specialists around the world for decision making.
- Hundreds of simultaneous data access can be made using any device having a web browser.
- Cloud data storage is distributed in nature, so there is fast storage and retrieval procedure

B. Telemedicine

Recently information and communication technologies have been surged to support and provide patient care services beyond the medical centers. Telemedicine technologies like telesurgery, audio/video conferencing, and teleradiology bring a new model for collaboration and communication between various healthcare stakeholders [5]. Telehealth care services not only allow patients to get clinical treatment without leaving their place but also help medical specialists to share their expert opinion to deal with complex medical cases.

Cloud based software could be developed to make possible the doctor-patient and doctor-doctor interaction as well as to facilitate the transmission and archiving of medical images. [9] proposed such a system to provide the treatment for distant dermatology patients. Cloud driven telemedicine services offers the following advantages:

- It offers live interaction between the participants without being at the same site.
- Patient medical data can be shared in real time across the geographical boundaries.
- It is flexible model as patients don't need to visit the doctor for getting a medical advice. Moreover, surgeons can retrieve the archived patient files at their own time and place.
- It saves on the patients' traveling cost and time. Medical specialists can adopt this model to reduce the unnecessary visits of patients thus saving their time.

C. Drug Discovery

Drug discovery is a process of discovering new medicines while ensuring its efficacy and any side effects. The process requires massive computing resources to identify the potential compounds for drug from a trillion possible chemical structures. Clouds against Disease, a joint venture of Molplex; Newcastle University; and Microsoft Research, introduce the cloud technology in drug discovery process. Thanks to the IaaS cloud, pharmacist can now borrow the computational infrastructure to analyze the huge biological [8]. This revolutionary technology has drastically decreased the cost and time for drug discovery.

D. Digital Libraries

Libraries are the prime source for knowledge improvement among medical students, researchers and practitioners. However, paper based medical libraries, particularly in developing countries, are not able to meet the demand of community due to the financial barriers. Cloud based digital libraries have been seen as an opportunity. Cloud providers can offer range of services to the libraries like file storage, indexing service, query languages, hosting service and library management systems [13]. Cloud library services bring the following advantages to the community:

- Institutions and individuals can avail the facility on demand.
- Several information seekers can read the literature, simultaneously.

- Information is readily available, as researchers don't have to sift through the pile of files.
- Semantic based query makes the searching process hassle-free.
- Physicians could get aware of current progress in medical domain and hence improve their work practice.

E. Virtual Medical Universities

Cloud computing has taken its roots in academia too due to its flexible and pay-as-you-go model. IT companies like Amazon, Google, Microsoft, IBM, and HP have been developing applications for both on-campus and off-campus support [3]. Medical universities can use this model to deliver online lectures, conduct seminars and to increase collaboration among academia around the globe. It can help medical institutions, particularly in developing countries, to reach a greater number of learners at low cost and less effort. Cloud computing service models can be effectively used for academic purpose as shown in Table I [3], [10], [11].

Table I: Cloud Computing for Academia

Cloud Service	Users	Applications
SaaS	Student, Faculty and Admin staff	Collaboration tools, teaching and learning software etc
PaaS	Developers	Software development, deployment and testing
IaaS	Researcher, Faculty, Admin staff, Students	Storage, computations, I/O, network etc

F. Management Information systems

Healthcare industry has started using management information systems to streamline the information flow within and outside the organization. Physicians use the system to provide better patient care; customers use it for querying service; administrators use this to manage the human resource, billing and finance; top management use this system for decision making and forecasting purpose [15]. These are the proprietary systems which contain the mission critical data about the organization. Due to the confidentiality of the information, developers can use PaaS cloud to develop, test and deploy this system. PaaS ensure the rapid collaborative development, cross-platform compatibility, and integration of the system with other legacy systems.

G. Clinical Decision Support System

It is an expert system that emulates the knowledge and behavior of a medical specialist to generate the advice upon the analysis of patient record. Doctors as well as patients may use these systems for the diagnosis and medication purpose [5], [2]. Cloud service providers (CSP) can develop these intelligent systems to support the patient care on demand. Advancement in smart phone technology with built in sensors for heart rate monitoring, blood pressure measurement etc

makes these cloud systems very ideal for real time medical care as patients can send their data to the system and get an advice. Quality of health care can be improved as physicians or patients use these systems to validate the treatment process [15]. Also, these systems can be used for patient care in emergency situations when doctor is not readily available.

H. General Health Education

Web is a wealth of information for masses to know about fitness, health, dietary and sanitation issues etc. Majority of people get health related information from the internet using trusted resources like web pages, helper groups, and blogs on particular disease type [15], [6]. Patients who already have suffered from a particular disease can share their knowledge, experience, dietary plan and medication process with new patients. However, these resources shouldn't be seen as an alternative of a physician [6].

Cloud services like PaaS and SaaS can be used to teach and train our masses about self-care. CSP can either provide hosting services to these resource owners or helpers can rent cloud applications like chat tools, forums etc to start their own group. Benefits of this community education include:

- Patients can quickly respond to the doctor's advice as they already learn from web about their condition and treatment [6].
- Health education at mass level can help to prevent and control the diseases.
- It makes the doctors accountable as patients don't blindly follow the doctor's advice; they can confirm from other patients with similar disease [15].
- Physicians and patients can know about the novel medication methods which are not yet widely in practice [15].

IV. CLOUD ADOPTION CONSTRAINTS

Though attractive but cloud computing adoption for healthcare service delivery is not free of challenges and risks. Limitations to the cloud based healthcare solutions include social acceptance, security and confidentiality of data, trust in cloud provider, data loss, data un-availability, country specific legislations and lack of standards for cloud system development [7], [1]. Some of the constraints are discussed below:

- Social acceptance is one of the major issues. Acceptability of these systems is not readily guaranteed as people are always afraid of emerging technologies. However, with the passage of time as individuals get acquaintances they will accept it as a part of their work need.
- Security and confidentiality of organizational data has been a paramount issue even in the existing e-health systems. Cloud service providers ensure hard-to-break encryption techniques and authentication rules [7]. Moreover, private cloud model or community model could be used to deal with this issue.
- Trust is another barrier for the shifting healthcare services to cloud. Many issues like quality of service, data loss,

providers' country legislations and data migration between clouds etc pose a serious threat to the clients. However, service level agreements (SLAs) can be used to measure the level of trust in cloud providers.

- Lack of standards for the development and deployment of cloud based healthcare solutions is still a burning issue. Developers can use the existing e-health system standards [1]. In addition, many agencies and regulatory authorities are working to come up with standards. Time is not far away when users will have a spectrum of standards available for cloud health systems.

V. CONCLUSION

Cloud is an economical model for delivering ICT services to business, institutions and enterprise. Concept of cloud technology in healthcare is not novel, but its adoption in healthcare industry is not mature yet. Many cloud based healthcare solutions already exist in their infancy. Need of the hour is to harness the application of cloud computing to its fullest. Cloud can help healthcare stakeholders not only to solve many of their existing problems but also to deliver quality healthcare services in a timely and cost effective fashion. However, at the same time cloud adoption in healthcare industry suffers some inherent risks like data security and privacy, lack of trust, organizational acceptance and unavailability of system development standards etc. Appropriate analysis, planning and measures should be taken into consideration before shifting to the cloud environment.

Research must be done to envision and implement the cloud based healthcare services. The confluence of interest between cloud technology and healthcare industry will result in new application and opportunities.

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